THE BRITISH ASSOCIATION

SECTION A—MATHEMATICAL AND PHYSICAL SCIENCE

On the Duty of the British Association with respect to the Distribution of its Funds, by Lieut.-Col. A. Strange, F.R.S.

It is probably well known to most men of science in England that the British Association succeeded, in 1870, in inducing Her Majesty's Government to appoint a Royal Commission to inquire into the whole question of scientific instruction and the advancement of science. The Commission is composed of the Duke of Devonshire (chairman), the Marquis of Lansdowne, Profs. Stokes, Sharpey, Huxley, H. Smith (of Oxford), Sir John Lubbock, Sir J. Kay Shuttleworth, Mr. Samuelson (members), and Mr. J. Norman Lockyer (secretary). This powerful body has, since its constitution, been sedulously engaged in taking evidence. That which relates to "Scientific Instruction" has been already published, and it is now engaged in the second branch of its inquiry, namely, the "Advancement of Science." It is to this latter branch that the present communication refers.

Since the movement was begun at the Norwich Meeting of the Association in 1868, great progress has been made towards the formation of definite views as to the duty of the State with respect to Science. As having been myself examined by the Commission, and as having been in communication with many of the witnesses who have appeared before it, I am able, without intending to anticipate the publication of the proceedings, to say that the following specific points have been forcibly and extensively brought under their consideration:—(1) That the objects of scientific teaching and of scientific investigation are distinct, and require for their respective attainment distinct machinery; (2) That the State is bound, in the interests of the community, to maintain institutions—such as laboratories and observatories—for scientific research, apart from teaching; (3) That all State scientific institutions and action of every kind should be subject to the direction of a single Minister of State; and (4) That such Minister of State should have the assistance of a permanent, paid, Consultative Council composed of eminent men of science.

Of these measures, unquestionably the most important are the two last—a Minister and a Council. I believe I am justified in saying that the Commission are giving their most earnest attention to those fundamental steps on which the whole fabric of a consistent administrative system for science must be based.

The question having reached this point, it appears to me that the British Association may well now consider how they may still further advance it; and I beg to tender a suggestion to that end.

Of all difficulties in the way of science reform which, in the course of my study of the question, has appeared to me the most obstructive, I should pick out the confusion of thought which prevails as to what scientific objects should properly be undertaken, as a duty, by the State, and what objects may be safely left to be worked out by private enterprise. The confusion of thought exists even amongst scientific men; and it is characteristic in a much more marked degree of the occasional references to science made by the Government and by politicians generally. It appears to me that the British Association has it in its power to clear up this most prejudicial obscurity, and to contribute powerfully to the much-needed scientific education of the Government.

I will here briefly allude to a few recent examples of the confusion of thought to which I allude.

Mr. Gladstone, on two late occasions—namely, at the anniversary dinners respectively of the Civil Engineers' Institute and of the Royal Society—expressed the opinion that the more science was left to itself the better for it. He termed the intervention of the State as "interference" with science, calculated to discourage individual exertion, and so obstruct discovery and progress. If this opinion be sound, let us see what its consistent application must lead to. It must logically mean that the Royal Observatory, the British Museum, the Ordnance and Geological Survey, and our various botanical gardens and other scientific institutions, should forthwith be abolished as "interferences." No one has yet ventured to recommend this.

Such a recommendation would no doubt at once be met, even by Mr. Gladstone, by a clear exposition of the great importance to the nation of such institutions, and of the reasons why they cannot be maintained in efficiency but by the State. At once his general and sweeping proposition would thus be shown to be liable to so many and such extensive exceptions as utterly to destroy it as the basis of the argument. He would have, therefore, to deal with each example of proposed State intervention on its merits, and, before resisting it, to show that either it was not needed by the community, or that, being within the fair scope of private action, Government aid could be dispensed with. And this, in fact, is the only way in which we can possibly test the claims of science on the State. It seems to me that to substitute the term "interfering with science" for the more correct one of "aiding science" is as fair and rational as it would be to term our Post Office an interference with freedom of correspondence, our Railways an interference with freedom of communication, or our Police an interference with the good order of community. Yet many persons, who will not give themselves the trouble to think, will accept a word falling from an eminent man like Mr. Gladstone, even when so grievously misapplied as this, and will found upon it the most mischievous conclusions. I do not doubt for a moment that Mr. Gladstone used the word in all good faith, but I am also forced to believe that he cannot have applied his powerful and logical mind to this subject with the same energy and earnestness which have given him the mastery of so many others of equal or greater difficulty. When he has given it his full consideration, as he will shortly no doubt have to do, I am confident he will withdraw from the indefensible position he lately assumed.

Another recent example of confusion of thought as to the duties of the State is afforded by the refusal of the Government to aid in tidal researches. A committee of the British Association—of which its late president, Sir William Thomson, is chairman—has been for several years engaged on this subject. The funds provided by the Association being exhausted, application was made to Government for 150*l*. in aid. Her Majesty's Lords of the Treasury replied in these words:—"That they are fully sensible of the interesting nature of such investigations, but that they feel that if they acceded to this request it would be impossible to refuse to contribute towards the numerous other objects which men of eminence may desire to treat scientifically. Their Lordships must, therefore, though with regret, decline to make a promise of assistance towards the present object out of public funds."

If we contrast this refusal of aid to tidal researches with the aid afforded to the two last expeditions to observe solar eclipses, we shall be forced to conclude that mere parsimony and indifference to science cannot have dictated it, but that our statesmen have as yet arrived at no principle whatever on which such questions should be dealt with. The importance of eclipse observations is very great, but such researches partake, in the present state of our knowledge, more or less of a speculative character, whilst tidal researches, though bearing on various high cosmical problems, contribute in the most direct and practical manner—obvious to the least scientific person—to the welfare of our commerce and navy, and to many other branches of national activity. Yet several thousands of pounds, with the use of ships, were freely accorded by Government in the one case, and 150*l*. refused in the other. Such extraordinary inconsistency can only arise from the absence of due knowledge on the part of Government as to what are duties of the State in science and what are objects fairly devolving on private exertion.

The question I would now ask is—How can the Association help to impart this indispensable knowledge to Government?

In my opinion this can be done by the adoption on the part of the Association of some more settled rule for aiding science than those which at present prevail. So far as I know, the Association is guided, in making grants, by two main considerations only—first, the total sum at their disposal; second, the number and relative importance of the objects proposed. Acting principally on these considerations the Association has, in my opinion, whilst prompted by the most sincere desire to advance science to the utmost, contributed somewhat to the confusion of thought to which I wish to draw attention. By aiding numerous objects which, under a systematic administration of science, would unquestionably devolve on the State, they have, I fear, helped to justify that undue reliance on the all-sufficiency of private enterprise which Mr. Gladstone expressed, and on which the Government, in the case of the tides and in many others, have acted.

The remedy for this evil—which is every day becoming greater—that I would now propose is that the Association, in making their grants, shall discriminate more than they have hitherto done between objects which are national and those which are not national; and that they should give the preference to the latter. I would further recommend that a list of national scientific researches requiring immediate attention should be forwarded yearly by the Association to the Government, with such advice as to the best mode of conducting them as may seem necessary; and that previous to each annual meeting the Association should request the Government to state what had been done with respect to such researches, the result being published in their annual volume of Proceedings.

It is not by any means my object nor my wish to bring the Association into collision with the Government. Such a result is strongly to be deprecated. But I do not believe it would follow from the course I suggest, whilst I see no other mode of putting in a practical form before the administration those urgent requirements of science on which so much of the material economy of the State rests.

The Association has undoubtedly the right to distribute funds entrusted to it by private individuals as may seem best for science. And being the most powerful scientific body in the kingdom, both intellectually and numerically, the duty properly devolves on it of endeavouring to remedy evils arising from imperfect knowledge of science wherever discernible. These two considerations afford an ample justification for the course I suggest, should it seem otherwise judicious.

It may be objected that no definite test exists by which we may discriminate between the two classes of scientific objects which for brevity I will call Public and Private. I therefore propose the following:—

Public science should be characterised by three principal features—(1) Continuity; (2) Probability of Expansion; (3) Unremunerativeness to the individual cultivating it, combined with profit or advantage to the community generally; (4) Costliness. Each individual research, properly Public, may not present all these three features in equal prominence, but with the great mass of questions which come before the Association there will be no difficulty, in most cases, in arranging each under the proper category. Cases of doubtful character must be classified according to the discretion of the Association, than whom no one can be more competent for the task.

I would here, in order to illustrate my meaning, mention a few typical cases of Public Science which the Association and other private bodies and persons have attempted to deal with. The Kew Observatory was one such case. An institution of that kind satisfies exactly all the three conditions constituting it, according to my definition, Public Science. It was discontinued chiefly on the ground that the cost of its maintenance, 600*l.* per annum, absorbed an undue proportion of the income of the Association. I was one of those who assented to its discontinuance, but on other grounds besides the one I have named. I considered that the annual sum spent upon it, though a large one relatively, was quite insufficient for such a purpose, that it needed great expansion, and finally that as long as such an institution existed, even on so contracted a scale, Government would not found a really sufficient one, as I considered they ought to do. After its relinquishment by the Association, Mr. Gassiot came forward and undertook the cost of its continuance. While offering my humble meed of admiration of such rare liberality, I must still say, what I urged when the arrangement was first proposed, that, though supplying to a certain extent a temporary want, it could not do so on the requisite scale, and that its effect would be to postpone the period at which Government would be able to see that such institutions must be maintained on the most liberal and comprehensive scale at the public expense. I also instance the subjects of Sewage, of Rainfall, of the Map of the Moon, and of the Tides, as bearing all the three characteristics of Public Science—and many others could be added. As to the Sewage question, the committee which undertook it no sooner began their labours than they perceived the utter inefficiency of the funds allowed by the Association. They sought to supplement these by appeals for help to the large towns, and questions of a delicate nature respecting the personal expenses of the members of the committee led to unpleasant consequences—the whole showing clearly that the subject was far too extensive, costly, and arduous for the powers and resources of private enterprise, and that it was, in fact, a national question which could be grappled with by national agency only.

As to the Rainfall question, it is well known that for several years Mr. Symons has devoted the greatest energy and skill to it, and that he has established a considerable number of rain-gauges all over the kingdom. He has received annual grants of money from the Association, but, unless I am misinformed, he considers the system which he has created still incomplete, and I believe he has incurred very considerable sacrifices in bringing it to its present condition. Now this case strongly illustrates the evil on which I have dwelt.

When, on the death of Admiral FitzRoy, the present Meteorological Office was established, no provision whatever was made for ascertaining the general rainfall of the kingdom. This, it was found, was being done by private enterprise, and the excuse for excluding one of the most important of meteorological elements from the programme of the State Meteorological Department was eagerly seized, although a little reflection would have shown that the very existence of the private system depended on the zeal and life of a single individual; indeed, it was threatened with total collapse that winter, in consequence of Mr. Symons' health failing from overwork.

The Map of the Moon was another large subject to which many eminent astronomers—of whom the late Sir John Herschel was one—attached much importance. The funds which the Association was able to furnish for the purpose being utterly inadequate, the project was abandoned. It is still kept alive by the zeal of Mr. Birt, assisted by a few friends; but its complete realisation by such means may be considered as indefinitely postponed. I am justified in assuming that the fact that the Association did make the attempt will be used, when the subject is pressed on the Government, as a proof that it is one properly devolving on private enterprise. I have already described the position of the Tidal question, which constitutes the most conclusive demonstration of the effect on the Government of such undiscriminating application of private funds and private enterprise.

I trust I shall not be considered, in consequence of what I have said on the subject, to depreciate or undervalue private enterprise. It is one of the just boasts of Englishmen that in no nation are there to be found such wonderful examples of individual zeal for high and unremunerative objects as here. Our colonisation, libraries, museums, hospitals and charities, the missionary agencies—all supported by voluntary means—surpass those of all the world put together. In some instances—as in that of our charities—private beneficence, for want of due direction, has actually gone too far and done harm. In science, also, England is pre-eminent for the number of observatories, laboratories, and other forms of activity maintained by individuals; whilst no civilised nation is so backward in its State organisation for science. The question I wish to raise is whether our private science, exuberant as it is, suffices for the national wants in the present age; and if not, whether the indiscriminateness of private scientific enterprise in England has not tended to induce the feeling that science is already sufficiently provided for, and does not need what Mr. Gladstone calls "the interference of the State."

I would strongly urge that no State organisation of science can possibly chill the zeal of private enterprise. The love of individual exertion, the pride of persona prowess, and the liberality of private wealth, are sentiments too deeply imbedded in the genius of Englishmen to be capable of such easy eradication. Nor will the Association find, that by the classification of scientific objects which I have recommended, there will remain of those which may properly devolve on individuals a number insufficient to absorb the moderate income which it has at its disposal.

The only other effect of such classification that appears to me open to possible objection is that some of the scientific objects which would otherwise be, however imperfectly, advanced by the help of the Association, may, by being referred to the Government, suffer total neglect. I at once admit that this effect will at first very probably take place in some instances. But for my own part I should be prepared to incur the risk of that sacrifice, in order to expedite a full consideration of the great question of the duty of Government towards science. The measure I propose is avowedly not intended to meet at once pressing temporary want, but to contribute to the creation of a great permanent system. It is my wish, not to ease, by small local applications, the sufferings of the patient, but to effect a radical cure. The treatment has as yet consisted of small expedients which, though they have given occasional relief, have not touched the seat of the disorder. I do not shrink from recommending, instead, a bold, if painful, operation that shall strike at the very root of the malady.

Report of the Committee for Discussing Observations of Lunar Objects Suspected of Change, by W. R. Birt.

The Committee have pleasure in presenting their Second Report on the above subject. It will be remembered that the Report of last year was confined principally to the discussion of the possible variations of visibility of the numerous spots and craterlets upon the floor of Plato under the same conditions of illumination. That now presented is directed chiefly to the discussion of the various streaks and bright patches which interlace the spots and craterlets. One interesting and important change has been fairly shown; the floor of Plato becomes darker with the increase of the sun's altitude, Mr. Birt has offered an explanation of the phenomenon; whatever be the true cause of this change, it is very difficult to account for it by the ordinary laws of reflection; when we consider the varying aspect of the streaks at the same time of the luni-solar day, we cannot but think that, with careful observations made with powerful instruments such as the Newall refractor and many others, we may be able to confirm or otherwise a physical explanation of these curious changes involving the existence of certain gases and vapours upon the surface of the moon. The Committee can only look upon the study of Lunar physics as in its infancy, and they trust that in future years the Association will not overlook this important branch of astronomical inquiry.

After reading this Report of the Committee, Mr. Birt read extracts from his report of the discussion of the streaks on the floor of the lunar crater Plato which had been entrusted to him, the opening portion was to the following effect:—

"In completing the task assigned to me of discussing the observations of the streaks on the floor of Plato, I have been desirous of including every, even the most minute circumstance bearing on the exhibition of phenomena that may possibly illustrate the condition of a small portion of the moon's surface from April 1869, to April 1871. Drawing my conclusions from the experience of twelve years, I feel that I may confidently say that it may be some years before another series of observations of a particular region will be undertaken with the view of so closely examining the spots and streaks characterising it, unless a staff of efficient observers be organised, with the provision of a fund sufficiently ample to defray all the necessary expenses. The work is a difficult one, the staff should consist of not less than six devoted observers who would independently and most probably, as in the present case, work with instruments of varying aperture, and carefully record all their observations. The principal qualification is a keen eye for the appreciation of delicate variations of tint and the detection of minute spots of light, with a readiness of referring them by estimation and alignment to the respective localities of the region on which they are seen. The observations should not be allowed to accumulate, but should be forwarded at once to an experienced selenographer charged with the work of arranging and discussing them. Taking into consideration the results of the discussions of the present and previous years embodied in the two reports, it appears that in order to confirm these results and to open up new investigations the requisite time cannot well be fixed at less than three years—five would most probably afford the best results.

"The results of the present work may be briefly characterised as confirming by a direct reference to the sun's altitude above the horizon of Plato the supposition that variations of tint in some measure depend on increasing and decreasing altitudes. The ascending and descending branches of the curve obtained from independent estimations of tint by the several observers, are sufficiently near those of the sun's altitude to enable me to delineate a normal curve representative of the sun's influence in darkening the floor of Plato, or else in overspreading it with something of the nature of a dark covering as his rays strike the surface at the increased angle of about forty degrees. While this darkening influence comes out most unmistakeably, there are variations in the lighter and darker portions of the floor which are quite irreconcileable with solar influence of a gradual character. The treatment of the observations under intervals of the luni-solar day fails to bring out any regularity in these variations, and it is only by treating the observations *chronologically* that the true sequence of the changes can be detected."

Mr. Birt proceeded to notice that in order to assist in showing more distinctly the changes observed on the floor of Plato and their connection with certain supposed agencies, he had introduced the *hypothesis* of a dark obscuring medium overlying the surfaces of the lower parts of the moon; he did not insist upon this hypothesis further than its utility in connecting the observations. The Report, which was rather voluminous, referred especially to the influence of the sun on the floor of Plato; an examination of the changes recorded in August 1869, formed a separate portion of the Report as well as the history of a single streak from its first detection in September 1869, to the close of the observations. A considerable portion of the Report consisted of "Notes" furnished by the several observers.

SECTION B—CHEMICAL SCIENCE

On Filiform Native Silver, by J. H. Gladstone, F.R.S.

The object of this communication was to show that metallic silver might be obtained artificially in the same filiform condition in which it frequently occurs in a mineral, and thus to throw light on the origin of this native variety. Specimens of the metal were exhibited, from Kongsberg in Norway, associated with calc-spar, and from Chili, associated with greenstone, and in each case the silver resembled twisted threads or wires non-crystalline, but often bending at sharp angles. Under the microscope were exhibited precisely similar threads of silver produced by the decomposition of nitrate of silver by sub oxide of copper. The latter substance is partly dissolved and partly converted into the black oxide, while filaments of the white metal shoot forth and bend in every direction. Most of these are extremely fine, perhaps $\frac{1}{25000}$ of an inch in thickness, so that, as was said, a gramme of such wire would stretch from London to Brighton. Since sub-oxide of copper is no rare metal, it seems probable that filiform native silver may often, if not always, originate from it.

SECTION C.—GEOLOGY

On the Occurrence of a remarkable Group of Graptolites in the Arenig Rocks of St. David's, South Wales, by John Hopkinson, F.G.S., F.R.M.S.

In a series of black, iron-stained shales, about 1,000 feet in thickness, which form the lowest beds of the Silurian rocks in the immediate vicinity of St. David's, the author noticed the occurrence of about twenty species of graptolite, which, he considered, furnished conclusive evidence of the equivalency of these beds with the Quebec group of Canada, the Skiddaw slates of Cumberland, and the Arenig rocks of Shelve.

The Graptolites, of which there are more than twenty species, were collected in the lower beds of the series at Ramsay Island and Whitesand Bay. Of the true Graptolites, or *Rhabdophora*, the only genera of undoubted occurrence are *Didymograptus*, *Tetragraptus*, and *Phyllograptus*. *Didymograptus* is represented by five species, three of which—*D. extensus* Hall, *D. patulus*, Hall, and *D. pennatulus* Hall—are characteristic of the Quebec group and the Skiddaw slates, *D. patulus* also occurring in the Arenig rocks at Shelve; the other species are new. Of *Tetragraptus* but one species, *T. serrus* Brong., also a Quebec and Skiddaw form, has been found. *Phyllograptus* also is only represented by a single species, which is new. There is also another new species—a very peculiar branching form referred provisionally to *Loganograptus*. The absence of any specimens undoubtedly referable to *Dictyograptus* is remarkable, as this is a common Quebec genus. *Diplograptus* and *Climacograptus*, genera of very rare occurrence in the Quebec group, have not as yet been found here.

Of the allied forms, all the genera of the so-called "Dendroid" Graptolites, so characteristic of the Quebec group, are present in the St. David's beds. *Phyllograptus* is represented by two new species, and *Dendrograptus* by five species, three of which—*D. divergens* Hall, *D. flexuosus* Hall, and *D. striatus* Hall—are at present only known to occur elsewhere in the Quebec group, the other not being new. *Callograptus* is also represented by five species, three—*C. elegans* Hall, *C. diffusus* Hall, and *C. Salteri* Hall—being Quebec forms, and two being new; and, lastly, of *Dictyonema* but one species, which is new, has been found. Many obscure impressions referred to the genus *Retiolites* also occur, one species seeming to agree perfectly, as far as its state of preservation allows of comparison with Prof. Hall's figures, with his *R. ensiformis* of the Quebec group. Another appears to be distinct from any species yet figured.

The Graptolites and their allies are now thus known to be represented in the Arenig rocks of St. David's by nine genera and about twenty-two species. Of the true Graptolites three genera—namely, *Tetragraptus*, *Loganograptus*, and *Phyllograptus*, are exclusively confined to the horizon of the Quebec and Skiddaw groups. The remaining genus, *Didymograptus*, is represented in higher rocks but by one species, *D. Murchisoni*. With this exception, *Didymograptus* is exclusively an Arenig genus occurring in rocks of this age in Canada, Cumberland and Shropshire. The four genera of dendroid Graptolites have a more extensive range, but until now they were only known to occur together and in any abundance in the Quebec group of Canada.

The author then stated that he could now give another locality for these genera. During a recent visit of the Geologists' Association to Ludlow and the Longmynds he had found, at Shelve, in the lower part of the Arenig rocks, underlying the great mass of the Llandeilo, a Graptolite zone in which these four genera are represented by species, some of which are identical with, and others nearly allied to, those in the St. David's beds and in the Quebec group of Canada; these beds, and also the Skiddaw slates of Cumberland, being therefore of Lower Arenig age.

Prof. Harkness, after referring to the labours of Mr. Hicks, remarked upon the occurrence at so early a period, of so many new forms of life, alluding especially to the discovery of a star-fish. He thought the name Skiddaw would be more appropriate for the beds immediately underlying the Llandeilo flags, than Arenig, although he acknowledged that the latter name was one which had been a long time in use.—Prof. James Hall, of Canada, on being called upon, said that he had examined the specimens on the table and was much pleased to find the Graptolites from St. David's so intimately allied to those he had described from the Quebec group; indeed had he not known where these specimens had been obtained he should have thought that they had really come from some of the beds in Canada. Allowing for differences caused by pressure and cleavage, the resemblance between these and the Canadian forms was truly remarkable.—Dr. Nicholson said that *Didymograptus* had a wider range than Mr. Hopkinson had given, several species of this genus being found in the Llandeilo flags in the south of Scotland and elsewhere.—Mr. Hicks, in his reply, said that he was pleased to find that Prof. Hall so thoroughly agreed with his ideas of these beds in regard to their equivalents in Canada. In reference to the remarks of Prof. Harkness as to the name of Skiddaw being preferable to that of Arenig, he said that as some of the rocks in the Shelve district which had for some time gone under the name Arenig, were now proved to be the equivalent of these beds, he thought it best to adopt this name.—Mr. Hopkinson, in reply to Dr. Nicholson's observation on the genus *Didymograptus*, stated that the species referred to by Dr. Nicholson, in his opinion belonged to a distinct genus to which he had given the name *Dicellograptus*, and which differed entirely in structure from *Didymograptus*. He was very glad to find his views of the equivalence of the St. David's beds, as shown by their Graptolites, with the Quebec group of Canada so decisively confirmed by Prof. Hall.

Saturday, August 17.—*Sur les divisions de la Craie en France, leurs limites et leur faune, l'identité de ces divisions des cotés du détroit*, by Prof. E. Hébert.

The author objected to the divisions of the chalk commonly adopted in England, into chalk with flints and chalk without flints. He proposed to subdivide the chalk according to the characteristic fossils of certain horizons, affirming that the divisions thus adopted were constant, and could be applied as well to the English chalk as to that of France. Taking the Gault as the natural base of the chalk, he classed the overlying beds, in ascending order, as follows:—1. *Craie glauconieuse* (Upper Greensand and Grey Chalk); 2. *Craie à Inoceramus labiatus* (Chalk marl, chalk without flint, and part of the chalk with flint); 3. *Craie à Micraster cor-testudinarium* (part of the chalk with flints); 4. *Craie à Micraster cor-anguinum* (chalk with flints); 5. *Craie à Belemnitella mucronata* (Norwich chalk).

Between the first and second divisions comes the great series of Sandstones of the Maine; and between the second and third division comes the Hippurite limestone. These beds are not represented on the coasts of the English Channel, but at the points where the "breaks" occur there are hardened beds of chalk, often pierced with holes.

The author showed that the chalk area of the North West of France is traversed by five well-marked anticlinal folds, which run in a general south-westerly direction, but converging somewhat towards the coast. These folds the author identified with some on the English coast.

Mr. Davidson then made some remarks upon Prof. Hébert's paper, pointing out that the Upper Greensand in parts of England assumes a much more important character than that given to it by Prof. Hébert. Prof. Phillips, Mr. Godwin-Austen, and Mr. Seeley also took part in the discussion, Prof. Phillips remarking upon the great good that results from meetings of this kind, at which geologists of different countries could meet and personally discuss their views.

Monday, August 19.—Three Reports were read at the commencement of the meeting. That by J. Thomson, *On the Continued Investigation of Mountain Limestone Corals*, dwelt upon the great difficulty which had been experienced in determining the species and genera of corals. The author showed that all systems of classification founded upon the arrangement of special parts of the coral were artificial and misleading. He had prepared careful drawings tracing the coral through the whole of its stages of growth, and he believed that only in this way could we arrive at satisfactory results.

Prof. Duncan and Prof. Jas. Hall both insisted upon the great difficulties that were encountered in classifying corals. It was clear from this discussion that in the corals at least there is no lack of the "intermediate forms" which Mr. Darwin assumes to have existed in all groups of animal and vegetable life.

Dr. Bryce, in his *Report on Earthquakes in Scotland*, said, that nothing of importance had occurred during the past year, no disturbance of the earth's crust or oscillation of the lakes had been observed. The attention of the committee had been turned to the remedying of those defects which from time to time are apt to occur with instruments long in use. It was stated that the Seismometer belonging to the Association, which now occupies the lower part of the parish church of Comrie, is of too complex construction for general use. Simpler and cheaper instruments have been constructed by Mr. Geo. Forbes, which will be distributed amongst the stations of the Scottish Meteorological Society, and the results obtained will be detailed in a future report.

Mr. W. Jolly's *Report on the Discovery of Fossils in certain remote parts of the North West Highlands*, was likewise richer in promise than performance. Certain work had been done in investigating the limestones occurring with the Laurentian Quartzites and Sandstones, but the best part of the report was the announcement that the clergy and schoolmasters of the district had entered warmly into the projects, it was therefore hoped that before the next meeting of the Association a good deal of valuable information as to fossiliferous localities would be obtained.

On the Geology of the Thunder Bay and Shabendowan Mining Districts on the North Shore of Lake Superior, by H. Alleyne Nicholson, M.D., D.Sc.

Having recently had an opportunity of accompanying an exploring party to the north of Lake Superior, the author had been able to examine geologically the silver-mining district of Thunder Bay, and the gold-bearing district of Shabendowan (sixty miles to the north-west of Thunder Bay). Having described the chief geographical features of Thunder Bay, the author gave an account of the series of rocks known as the "Lower and Upper copper-bearing series." The chief argentiferous lodes were also described, and the more important mines were shortly noticed. The leading geological features of the country between Thunder Bay and Lake Shabendowan were next glanced at, and a detailed account was given of the geology of Lake Shabendowan itself The most interesting rocks described are the so-called "talcose" slates, in which the auriferous lodes are situated. These slates are of Huronian age, and they occupy, along with interstratified and intrusive igneous rocks, a vast area, which extends to an unknown distance north of Lake Shabendowan. Having described their mineral characters, the author expressed his opinion that these "talcose slates" are truly of the nature of bedded felspathic ashes, and that the talc which they often contain is a secondary product developed in them as the result of the metamorphic action to which the whole series has evidently been subjected. It was shown also that these Huronian slates, with their interstratified traps, presented the most striking resemblance to the Borrowdale series of green slates and porphyries of Cumberland and Westmoreland. The paper concluded with a description of the chief auriferous veins which have hitherto been found traversing these rocks.

On Ortonia, a new genus of Fossil Tubicolar Annelides, with Notes on the Genus Tentaculites, by H. Alleyne Nicholson, M.D.

Having recently had the opportunity of carefully investigating the genus *Tentaculites*, the author was led to the conclusion that fossils of diverse zoological affinities had been included under this head (Amer. Jour. Science and Arts, vol. iii. 1872). The author showed that some fossils formerly referred to *Tentaculites* were truly Pteropods, whilst others were genuine tubicolar annelides. For some of the latter he had proposed the genus *Conchicolites;* and he restricted *Tentaculites* to straight unattached conical tubes. With this restriction the genus may safely be regarded as Pteropodous, since no Pteropod has an irregularly bent or twisted shell, and none can possibly have a shell attached parasitically to foreign bodies. In the present communication the author founded a new genus for the reception of a fossli which had been kindly sent him by Mr. Edward Orton, of the Geological Survey of Ohio, after whom he proposed to name the genus *Ortonia.* This fossil had formerly been referred to *Tentaculites*, and is of common occurrence in the Lower Silurian (Hudson River group) of south-western Ohio. No doubt can possibly be entertained as the proper reference of this fossil to the tubicolar annelides. Only a single species is known, which the author named *O. conica*, and this occurs in the form of conical tubes attached by the whole of one surface to the shells of Brachiopods and other molluscs, *Strophonema alternata* being the form which is most commonly infested in this way. The sides of the tubes are furnished with strong annular ridges, which die away upon the dor al surface, leaving a narrow vacant space or belt of a peculiar cellular character, exhibiting numerous small alveoli, strongly reminding one of the peculiar cellular structure of the tube of *Cornulites.* From this latter *Ortonia* is separated by the complete attachment of the tube along one side, and by its much smaller size. From *Conchicolites* it is distinguished by its mode of attachment, and by never growing socially in clustered masses.

The Rev. Canon Tristram's paper *On the Geology of Moab* was then read. After referring to the researches of M. Lartet and others, the author described the general structure of the southern end of the Jordan valley, which, he said, coincided with a great synclinal depression. The lowest rocks exposed are New Red sandstone; these occur only on the east side of the Jordan, and are there capped by tertiary limestone, resembling that of the "back-bone" of Palestine. Abundance of springs break out at the junction of the limestone and the New Red, rendering the eastern shores of the Dead Sea very fertile. On the west side only three springs occur, and, excepting near these spots, the country is barren. Great deposits of marl are heaped against the western banks, but only a little of this occurs on the eastern side. Many streams of basalt occur on the eastern side of the Dead Sea. These overlie the tertiary limestone, and are, therefore, of later age than that. The origin of the lava flows is not yet known—no craters were observed in this district.

To the north-east of the Dead Sea, on the east of the New Red plain, there is a range of hills formed of tertiary limestone. Beyond, to the east of this, the Arabs tell of a vast volcanic tract, covered wlth ruined cities, which is as yet wholly unexplored.

In the course of the discussion, Prof. Hull remarked that the statements of the author gave a good example of the formation of a valley by disturbance, and he thought that comparatively little was due to denudation. Mr. Topley thought that even if a fault or synclinal ran along the valley, yet the valley itself was still due to denudation. Even if this were not the case, there was the line of hill, or an escarpment of tertiary limestone, on the north-east of the Dead Sea. The westerly continuation of this had been removed by denudation. He saw no reason why the whole of this denudation should not have been subaërial, the material having been carried southwards down the continuation of the Jordan valley before the great depression was proved. All the evidence compels us to believe that the great depression is of extremely recent geological age.

Canon Tristram, without giving an opinion as to the denuding agents, thought that the valley of the Jordan was marked out, and in great part formed by disturbance. In reply to Mr. Sharp, he said that the Moabite stone was a block of basalt of the country. Many such blocks of basalt are preserved at the houses there. In reply to Mr. Scott, he observed that the great deposits of salt at the southern end of the Dead Sea were of New Red sandstone age. The great saltness of the Dead Sea is mainly due to this salt being washed down by streams. Salt occurs all along the line wherever the New Red sandstone has been brought up, as in the Sahara and elsewhere.

On the Trachyte Porphyries of Antrim and Down in the North of Ireland, by Prof. Edward Hull, F.R.S., Director of the Geological Survey of Ireland.

Trachyte is one of the rarest of the British rocks, and it is as yet uncertain whether it is to be found amongst these islands except in the North of Ireland. In this district it was discovered and identified by the late Prof. Jukes and Mr. Du Noyer during the progress of the Geological survey in the year 1867. No description has as yet been published of this remarkable species of volcanic rock, and I propose to give a short account of its characters and relations to the surrounding formations as it occurs both in Antrim and Down.

Trachyte Porphyry of Antrim.—The principal mass forms a group of eminences about four miles to the north of the town of Antrim, called Tardree mountain, Carnearny Hill (1,043 ft.,) Brown Dod Hill and Scolboa Hill. The tops of three of these hills are formed of basalt in beds capping the trachyte rocks, and it is supposed that basaltic sheets enclose the whole of the trachytic district; though the survey of the district being incomplete the actual limits have not been determined in every direction.

The mineral constitution of the trachyte is generally uniform, although the relative proportions of the individual minerals occasionally vary. In general, the rock consists of a nearly white or grey felspathic base, with individual crystals of Sanidine, a triclinic felspar, blebs or grains of smoke quartz, and rarely a little mica. In some places the grains of silica are exceedingly abundant, giving the rock the appearance of Rhyolite or Perlyte as described by Cotta, minute crystalline grains of magnetite appear in a sliced section under the microscope. It is in this state that the iron mentioned in the analysis below probably occurs.

The rock is quarried as a building stone at Tardree mountain, where it sometimes assumes a columnar structure. A specimen from one of the quarries was subjected to an elaborate analysis by Mr. E. T. Hardman, of the Geological Survey of Ireland, who gives the following as the constituents:—[*]

Analysis of Trachyte Porphyry, Tardree quarry.

Silica	76·960	per cent.
Alumina	5·101	,,
Peroxide of Iron . .	2·344	,,
Lime	7·064	,,
Magnesia	0·294	,,
Potash	4·262	,,
Soda	1·818	,,
Loss by ignition . .	2·102	,,
Phosphoric acid . .	trace	
	99·943	
Specific gravity	2·433	

Relations of the trachytic and basaltic rocks. — During a recent visit I was enabled to ascertain with the greatest certainty the relative position of the trachytic to the basaltic rocks of the district. In the first place, there does not appear to be any passage or graduation of the two classes of volcanic rock into each other, and each having been erupted and spread out in sheets, exhibits a laminated, or bedded structure, which enables the observer to determine their relative positions without much difficulty. Both at Carnearny and Tardree Hills the trachytic porphyry may be observed to dip beneath the basaltic rocks of the surrounding country; and the observations made here and elsewhere tended to show that, of the two kinds of rock, the trachyte is the older.

On the other hand, both at Carnearny Hill and Scolboa the trachyte seems to have been penetrated by "necks" of later date filled with basalt, from which some portions of the overlying basaltic sheets may have been erupted. We are not, however, as yet in a position to say whether or not the trachyte is the oldest and lowest of all the Tertiary Volcanic rocks of County Antrim, as its base is nowhere exposed.[†]

The events which have taken place in the volcanic history ot this locality appear to have been as follows:—

At some early stage of the miocene period large masses of trachytic rocks were poured forth from one or more vents, doubtless accompanied by craters as in Auvergne. After, probably, a long interval of repose new interruptions of basalt and dolerite took place through fissures and small volcanic vents breaking in some places through the trachyte. These later eruptions of basalt may have enveloped the whole of the trachytic masses which have been subsequently laid bare by denudation. The denudation of this region has been very great during postpliocene and later times; and to it is due the obliteration of the actual craters of eruption over the whole volcanic region of Antrim.

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[*] Jour. Roy. Geological Soc. Ireland. Vol. iii. part i. p. 27. (New Ser.)

[†] Messrs. Hull and J. L. Warren. Explanatory memoir to sheet 36 of the Geological Survey of Ireland (1871).

Trachyte Porphyry of Co. Down. This rock is very similar in appearance and constitution to that of Antrim, consisting of a greyish felsitic base with crystals of sanidine and blebs of quartz. It is only visible at Ballyknock, about four miles west of Hillsborough, surrounded on all sides by Lower Silurian rocks, but not very far distant from the margin of the basaltic plateau of Antrim. There can be little doubt that it is of the same age as the trachyte porphyry of Antrim; both being referable in all probability to the great volcanic outbursts of the miocene period.

Considerable uncertainty exists regarding the relations of the Downshire trachyte to the volcanic rocks of the adjoining country. It only appears in two or three spots within a small area: but the probabilities are, that it is portion of an old neck from which trachytic lava was erupted contemporaneously with that of Antrim, the higher portion of the mass as well as the original vent having been removed by denudation. The district has since been deeply buried beneath boulder clay.[*] The author then proceeded to show the similarity of the Antrim volcanic rocks with those of Auvergne, the Siebengebirge and Eifel districts.

SECTION D—BIOLOGY

SUB-SECTION ZOOLOGY AND BOTANY

On the Occurrence of the Supra-Condyloid Process in Man, by Prof. Struthers, of Aberdeen.

The author showed dissections of this part in several animals. An arch of bone is thrown, like a bridge, over the great nerve, and generally also the great artery of the limb, a little above the elbow, protecting them from pressure and injury. No such structure exists normally in the human arm, but it occurs occasionally as a variation. When it exists, the process grows from exactly the same spot as in animals which possess it, and the arch is completed by a ligament, the nerve and generally also the artery passing through the arch. This variety had attracted some notice lately, and is supposed to be very rare, but the author has found it often, and he exhibited a large number of specimens of it from the human arm, in its various degrees of development. He had also met with it occasionally in the living body, and had lately been able to prove the correctness of his previous supposition that it may be hereditary, having met with it in the members of a family, in the father and in two sons. The author remarked on the great interest attaching to this variation. In animals which possess it, it is what, in olden phraseology, would be called a contrivance specially designed for the protection of the nerve in them, and it looks as much a piece of contrivance as London Bridge or Temple Bar. But why should the same contrivance occur as a variety in man? The old argument from final cause, and no less its successor the theory of "type," besides being metaphysical, becomes untenable in the face of the existence of these rudimentary structures. The theory of so-called type has a great deal to answer for in obscuring the natural interpretation. If species are of independent origin, how comes it that animals have in their bodies parts of other animals, parts which are of no use to them, sometimes even dangerous to them? To those who are able to overcome the prejudices of their early education, the evidence comes with irresistible force in support of the hypothesis of the origin of species by evolution.

On the Sternum and Pelvic Bone in the Right-Whale and in Great Fin-Whales, by Prof. Struthers.

The sternum exhibited showed a very different form from that of the same species of Fin-Whale which Prof. Struthers had brought under the notice of the Association last year. Instead of a singled median cervical process, it has a deep median notch with a broad crest on each side; and the posterior process is very narrow. Two sterna of the Greenland Right-Whale exhibited were large. The author divides the sternum into three parts. The middle between the first ribs is thick, completing the thoracic girdle, and essential. The part in front of this, and the part behind it vary greatly, being more or less rudimentary. The sternum of the Finner has two joints with the first rib, that of the Right-Whale only one joint, and this difference in the thoracic adaptation, together with the great breadth of the first rib in the Right-Whale, might explain the very different forms presented by this bone in these two kinds of whales.

One of these breast-bones exhibited marks of former inflammation of the bones. The author mentioned that he had often met with this condition in whales, in some cases ankylosis of vertebræ had resulted, and in some there must have been considerable suffering to the animal. This fact might be commended to the notice of those, if there be yet any such, who have the notion that disease occurs in animals only when they come under the influence of man.

On the Occurrence of Finger Muscles in the Bottle-Nose Whale (Hyperoodon bidens), by Prof. Struthers.

This bottle-nose stranded on the Aberdeenshire coast just after the meeting of the Association last year at Edinburgh, at which the author read an account of the finger-muscles in the great Fin-whale, first noticed by Prof. Flower. It had been believed that these muscles do not exist in the toothed whales, but in this bottle-nose they were even better developed than in the Finner. The extensor muscles especially were better marked, the external extensor, corresponding to the so-called extensor of the little finger of man, being also present. An extensor *carpus radialis* was also present. Besides the muscles which were known to exist at the shoulder and arm in the Cetacea, he found a representative of the biceps present here. These muscles were mainly to be regarded as rudimentary, but they had a certain low amount of function by which their presence as muscles is maintained. In some other cetaceans they are represented entirely by fibrous tissue. Prof. Struthers exhibited also a dissection of the rudimentary teeth concealed in the gum of this bottle-nose. They are alive but useless, and their presence could be reasonably interpreted only by the hypothesis of evolution.

SUB-SECTION ANTHROPOLOGY

Exploration of some Tumuli on Dartmoor, by C. Spence Bate, F.R.S.

The author had examined several cairns of the usual kind common on Dartmoor with but little success; they apparently had been previously rummaged by unknown hands. In one, a broken urn and an implement of white slate was found; the latter was supposed to have been that with which the potter formed the rude urn.

On Hamel Down, near the centre of Dartmoor, the author explored a barrow composed of earth surrounded with small stones; in this he found, beneath five large stones which were placed horizontally one beside the other, some burnt bones on the ground, a bronze dagger blade, and an amber ornament inlaid with gold, which is supposed to have been the extremity of the handle of the dagger.

The author contends that from the character of this interment, the burnt bones not being enclosed within an urn, and the amber ornament taken together with the names associated with the locality, are evidence of an early incursion of the old Scandinavian Vikinger in search of that tin which was necessary for them to manufacture their bronze.

On the Ethnological and Philological Relations of the Caucasus, by Hyde Clarke.

This paper communicates the further researches of Mr. Hyde Clarke on the classification of the languages of the Caucasus. It identifies (1) the Ude with the ancient Egyptian and Coptic; (2) the Abkhass with the Agau, Falasha, &c., of the Upper Nile; (3) the Circassian with the Dravidian; (4) the Georgian, Lazian and Sivan with the Caucass—Tibetan. The Ude and Abkhass are connected with the statements of Herodotus (Book II.) as to the Egyptian colony established in Colchus by Sesostris. Mr. Hyde Clarke observed that the Caucasus was not a centre of population for the world, but a place of passage, and showed the relations of the Abkhass (Agau) and Circassian with the Ougeners in Europe, Africa, Asia, Australasia, and America, illustrating the common population of the new and old world, and the knowledge of America by ancient nations, dimly preserved, though not understood by the Greek and Roman geographers.

The Origin of Serpent-worship, by C. Staniland Wake.

After referring to various facts showing the existence of serpent-worship in many different parts of the world, the author proceeded to consider the several ideas associated with the serpent among ancient and modern peoples. One of its chief characteristics was its power over the wind and rain; and a second, its connection with health and good fortune, in which character it was the agathodæmon. It was also the symbol of life or immortality, as well as of wisdom. This reptile was viewed by many uncultured peoples as the re-embodiment of a deceased ancestor, and descent was actually traced by the Mexicans and various other peoples from a serpent. The superstition thus became a phase of ancestor worship, the superior wisdom and power ascribed to denizens of the invisible world being assigned also to their animal representatives. When the simple idea of a spirit ancestor was transformed into that of the Great Spirit, the father of the race, the attributes of the serpent would be enlarged, and it would be thought to have power over the rain and hurricane. Being thus transferred to the atmosphere, the serpent would come to be associated with nature or solar worship. Hence, the sun was not only a serpent-god, but also the divine ancestor or benefactor of mankind. Seth, the traditional divine ancestor of the Semites, was the serpent sun-god, the agathodæmon, and various facts were cited to establish that the legendary ancestor of the peoples classed together as Adamites was thought to possess the same character. It appeared that serpent-worship, as a developed religious system, originated in Central Asia, the home of the great Scythic stock from which the civilised races of the historical period sprung, and that the descendants of the legendary founder of that stock, the Adamites, were in a special sense serpent-worshippers.

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[*] Mr. Hardman considers that the amount of lime shown by the analysis, proves that the trachyte has undergone some amount of metamorphosis or alteration, and considers it probable that it is consequently older than the basalt of Antrim, a view which subsequent examination in the field has enabled me to verify.

Sir Walter Elliot read a paper *On Some of the earliest Weapons in Use among the older Inhabitants of India.* These he traced to a curved "throw-stick" resembling, but differing from, the Australian bomerang, in as much as it does not return to the hand when thrown. The Indian "throw-stick" is found among the rude races inhabiting the mountain and forest tracks of Central and Western India, as the Dhangars, Kolis, and Gonds, and more to the South, the Kallars, Marawars, and other low castes. In waste and jungle tracts the people turn out in great numbers during the hot season, commencing with the first day of Hindu new year in March, and continued on every succeeding Sunday till the Monsoon begins. Hares, deer, hog, pea-fowls, partridges, &c., raised by this lowly race of beaters, each carrying a "throw-stick," are knocked over by showers of these weapons, thrown with great force and precision.

From the form of such sticks, which are from 1½ to 2 feet long and 3 to 6 inches broad, thrown with the concave side foremost, the author deduced the form assumed by the iron weapons subsequently formed by the same races. Specimens of these were exhibited, such as the Gurkha knives of Nipal, those of the Nairs, Moplas, and of the Malabar coast, and the common woodman's knife used everywhere, and which the late Capt. Forsyth states the Gonds, Bygas, and other tribes of the central Highlands throw at game with wonderful precision. These remarks apply more particularly to the Druoidian races, although not exclusively so. The earliest or aboriginal people now represented by the servile classes, seem to have used stone implements like people of the same condition in Europe and elsewhere, while the early Aryans passed through a bronze or copper period—specimens of the weapons of which era were exhibited.

Sir Walter observed that Prof. Huxley in classifying the varieties of the human race, exclusively for physical characters, had included under one head the people of New South Wales, of the Highlands of Central India, and of Ancient Egypt, all of whom he includes under the term Australoid. Now it is a remarkable coincidence that among these three far distant peoples the "throw-stick" was the weapon of the chase, and that examples do not occur in the intermediate countries. The pictures in the tombs of the kings at Thebes represent hunting scenes in which the curved sticks found at this day in India are extensively represented. The bomerang of Australia is precisely of the same form, but, being thinner and lighter, is so fitted to have a recoiling property.

SECTION E.—GEOGRAPHY

On the Orography of the Chain of the Great Atlas, by John Ball, F.R.S.

The representations of the chain of the Great Atlas given on the most modern maps show how very vague and incomplete our knowledge still is. They agree in very little beyond the fact that high mountains extend in a nearly direct line from the west coast, where they approach the Atlantic, near Agadir, in about 30° 30′ N. lat. for about 500 miles inland, where they subside at no great distance from the frontier of Algeria about the parallel of 33° 30′.

All but the most recent maps indicate a single range similar in general character to that of the Pyrenees, while in these we find represented two nearly parallel ranges at an average distance of sixty or seventy miles, of which the northernmost alone terminates near the Algerian frontier, its axis lying exactly in the line of the great shallow lakes, or chotts, that occupy a great part of the high plateau of southern Algeria, while the southern range, with some slight interruption, is continuous with the elevated zone that forms the northern limit of the Algerian Sahara. The details, however, as given in these recent maps, are strangely discordant, especially in regard to the region lying E. and N.E. from the city of Morocco, and connecting the main range with the mountains of North Morocco.

It is not surprising that such discrepancies should exist, when it is known that the best maps have been compiled with no better materials than the reports of natives, and that none but a very small portion of the entire region has ever been traversed by civilised men. In regard to Gerhard Rohlfs, one of the most remarkable of recent African travellers, it must be remembered that he was forced to maintain a rigid disguise, to associate constantly with natives, and to suit his movements to theirs. He was unable to make more than scanty and occasional notes, and was altogether debarred from the use of instruments. It is not surprising that, under such conditions, his contributions to the topography of a region never before visited by European traveller tend more to excite than to satisfy curiosity.

During the spring of last year the Sultan of Morocco, at the request of the British Minister, Sir John Drummond Hay, granted permission to Dr. Hooker, the eminent Director of the Royal Gardens at Kew, to explore the portion of the Great Atlas subject to the Imperial authority; and although the main object of the party, consisting of Dr. Hooker, Mr. Maw, and myself, was to investigate the Flora of the mountains, it might not unreasonably be expected that we should be able to make some considerable addition to existing geographical knowledge in regard to a region so little known.

Those who are best acquainted with Morocco will be least surprised to learn that in this respect the expedition has not borne abundant fruit. The obstacles which stood in the way were partly anticipated by us, but were in great measure insuperable.

The authority of the Sultan extends over but a small portion of the region included under the denomination Great Atlas. It is in fact limited to the northern declivity of the main chain, and only throughout the western part of this, for it extends to a distance at the utmost not more than 120 miles E. of the city of Morocco. The time at our disposal was too limited to enable us to explore even the limited field that was thrown open to use The cares and responsibilities attaching to his official duties prevented Dr. Hooker from prolonging his stay in and near the mountains beyond about three weeks, and the private engagements of Mr. Maw compelled him to separate from us and to return to England at a still earlier date. But by far the most serious obstacle which we encountered arose from the persistent though covert opposition of all the persons holding local authority, aggravated and not seldom stimulated by the chief of our escort, whose charge, as we had been assured, was to remove all impediments from our path.

But for the difficulties incessantly placed in our way, we should undoubtedly have attained several of the higher peaks, and could not fail to have learnt a good deal respecting the disposition of the greater masses and the direction of the main valleys in the territory which we could not actually traverse.

In point of fact we were able to make but two considerable ascents. On the first occasion, when we ascended the Tagherot Pass in a storm of snow and hail that completely intercepted all distant view, the cold was so severe that we willingly turned our faces from the storm when only Mr. Maw, the foremost of the party, had actually set his foot upon the summit, about 12,000 feet above the sea level. On the second occasion, after Mr. Maw had departed from us, we attained a conspicuous peak, called Djebel Tezah, about 11,500 feet in height, in a much lower part of the range than that previously visited. In addition to the very limited results of personal observation, we naturally availed ourselves of every promising opportunity for obtaining topographical information from natives. Much of the information obtained in this way appears to me utterly unreliable, especially when derived from persons holding local authority, but the particulars supplied by a very intelligent Jew residing in Morocco, so far as they rest on personal knowledge, deserve more confidence.

The following are the chief points as to which I think myself entitled to express an opinion, premising that as to some of them I may place undue confidence in my own personal conclusions:—

1. The portion of the Atlas chain that is seen from the city of Morocco is considerably higher than has generally been supposed. The higher summits approach nearly to the same elevation, and the majority of these approach very nearly, if they do not occasionally surpass, the level of 14,000 feet. Westward of the district of Glaoni, S.W. of the city of Morocco, the range subsides gradually as it approaches the coast.

2. There is a certain amount of tolerably good evidence tending to show that the interior part of the range extending from the upper valley of the Wed Tessaout to Eastern Morocco contains peaks of higher elevation than any seen by us.

3. The existence of an anti-Atlas or range parallel to the main chain, and enclosing on the south side the great valley of the Sous, was established by Rohlfs, if not by previous travellers; but we are probably the first who have looked across the wide intervening space and scanned the outline of the anti-Atlas. The portion seen by us at a distance of from 50 to 60 miles is far less bold in form than the main range. The utmost height of that portion can scarcely exceed 10,000 feet.

4. The map, compiled by Capt. Beaudouin, and published in Paris at the Depôt Général de la Guerre in 1848, which is decidedly the best that has hitherto appeared, is defective in representing the main chain as arising abruptly from the low country, scarcely indicating considerable lateral valleys. At the same time it should be remarked that the projecting ridges which divide these lateral valleys appear to be lower in comparison with the peaks of the main chain than is usual in other great mountain ranges.

5. There is a marked tendency to the formation of considerable valleys parallel to the main chain, and in such cases the remark made in the last paragraph does not apply. Some of the higher peaks, and amongst them those named Miltsin by the late Captain Washington, lie in ridges nearly parallel to the main chain.

6. It appears at least possible that the Anti-Atlas, if we may so denominate the range forming the southern boundary of the Sous Valley, is merely an example on a large scale of one of the parallel ridges just referred to, many examples of which are to be found in better known mountain regions.

7. The existence of two parallel chains so continuous as those represented in Gerhard Rohlfs' map appears to be open to reasonable doubt. In the absence of direct evidence, it appears at least equally probable that the conformation of the main chain may be best represented by a series of ridges slightly inclined to the axis of elevation of the entire mass.

8. The remarkable valley of the Beni mquald, laid down on Beaudouin's map as extending more than one hundred miles from S.E. to N.W. in a nearly direct line must be pronounced imaginary or based on false information. The details given in Rohlfs' "Reise durch Marokko," however incomplete, are manifestly inconsistent with the general plan of the mountain system laid down in that map.

SECTION G—MECHANICAL SCIENCE

Experiments on Surface Friction in Water, by W. Froude, F.R.S.

The object of investigation was to determine the laws which govern this force, in those especial relations under which it forms a portion of the resistance experienced by a ship when moving through the water at various speeds.

These are, (1) the relation of the force to the speed, (2) its relation to the quality of the surface, (3) its relation to the length of the surface along the line of motion. The necessity of investigating it under the latter of these relations, may not be at once obvious, it having been generally held that surface friction varies directly as the area surface, and will be the same for a given area whether it be long and narrow or short and broad. But a little reflection shows that this cannot be so, because the portion of surface that goes first in the line of motion, in experiencing resistance from the water, must reciprocally communicate to the water motion in the line in which itself is moving, and, consequently, the portion of surface which succeeds the first, must be rubbing, not against stationary water, but against water partially moving with it, and cannot experience as much resistance from it.

The experiments were performed with carefully-made apparatus, which automatically recorded the resistance and the speed, and the errors and uncertainties of the results probably did not in any case exceed on the whole $\frac{1}{2}$ per cent.

The surfaces used in the experiments were of yellow pine board, about $\frac{3}{16}$ of an inch thick, loaded at the edge with lead keels of the same thickness, fastened fair and flush with the board, the weights being such as to just neutralise the flotation, and hold the boards stably in a vertical plane. The head end (so to call it) of each board in turn was fastened into a tin sheath, or fine-edged cutwater, which formed a portion of the dynamometric apparatus, and which held the board resolutely in a vertical plane, with its length horizontal, and in the line of motion. The width of each board, including the lead keel, was 19 in., their lengths, including the cutwater, varied from 1 ft. to 50 ft. Great pains were taken, and successfully, to eliminate, and, indeed in effect to obliterate the resistance due to thickness.

It turned out that the effects of the three conditions under which the variations of the force were to be determined, could not be regarded as absolutely independent of each other, because certain variations in the quality of the surfaces were found to affect in some degree the relations of the force to the speed and to the length. The results may be approximately stated in brief, as follows:—

1. As regards the relation of resistance to speed. With the surface coated with shellac varnish, Hay's composition, or Peacock's composition, or tallow, the resistance varied very nearly as the power 1·83 of the speed; with the surface coated with tinfoil, very nearly as the power 2·05 of the speed; but the experiments with the tinfoil are not yet complete.

2. As regards the relation of resistance to quality of surface. With the surface coated with shellac varnish, Hay's composition, Peacock's composition, or tallow, the resistance differed extremely little; such variations as occurred scarcely exceeding 1 per cent., and being probably not greater than belonged to the small differences of smoothness in the laying on the composition.

With the surface coated with glue, and thus simulating the sliminess of a living fish, three successive experiments were tried at the same speed, so as to test the effect of the gradual growth of the slimy character. The first experiment showed an increase in resistance of 2 per cent., the last of 4 per cent., as compared with the shellac surface which the glue resembled before immersion, a proof that the attempted imitation of the fish's surface was not advantageous.

Comparing a tinfoiled surface with one coated with shellac, when the length is 1 ft. the resistance of the former is on the average only $\frac{2}{3}$ that of the latter, making the comparison with planes of 1·6 in length, the ratio is $\frac{3}{4}$, and with planes of 16 ft., more than $\frac{9}{10}$, instead of $\frac{2}{3}$; indeed, the total difference becomes progressively less as the planes compared are longer. At higher speeds also the difference tends to become less, in consequence of the higher power of the speed to which it is proportioned with the tinfoiled surface.

3. As regards the relation of resistance to length of surface. There plainly is a very considerable diminution of average resistance per square foot as the length of surface is increased, and this probably from the course already indicated, though the *rate* of diminution becomes gradually less as the surface becomes longer; there is, in fact, as great a diminution between 3 ft. and 4 ft. of length as between 30 and 50.

The following tabular statement gives the mean resistance per square foot on surfaces of from 1 foot to 50 feet in length, with speeds of from 200 to 800 feet per minute.

Length of plane. Feet.	Speed in feet per minute.				
	200	400	600	800	
1	0·048	·200	·460	·830	Resistance in pounds.
2	·045	·188	·413	·725	
3	·043	·183	·390	·673	
5	·042	·166	·358	·608	
7	·041	·154	·333	·563	
10	·040	·145	·312	·529	
20	·036	·131	·278	·473	
30	·035	·123	·264	·446	
50	·035	·117	·250	·417	

The table is applicable to a clean planed surface coated either with shellac varnish, Hay's or Peacock's composition, or tallow.